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CONTINUUM MODELING OF CATASTROPHIC COLLISIONS

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Conventionally, the debris from active comets has been thought to give rise to the zodiacal cloud. However the Infrared Astronomical Satellite's (IRAS) discovery of interplanetary dust bands associated with asteroids suggests that asteroids are a likely source for at least some of the zodiacal dust complex. Catastrophic collisions between asteroids produce the dust which maintains and replenishes the population of the dust bands. In an effort to better understand collisions between solid bodies, we report here on the development of a continuum damage model to study an impact event, where fracture growth, fragmentation, and stress wave propagation are predicted as a function of time.

A two-dimensional hydrocode based on Los Alamos' 2-D SALE (Amsden et al., 1980) has been modified to include strength effects and Grady and Kipp's (1980) fragmentation equations for fracture resulting from tensile stress in one dimension. Output from this code includes a complete fragmentation summary for each cell of the modeled object: fragment size (mass) distributions, vector velocities of particles, peak values of pressure and tensile stress, and peak strain rates associated with fragmentation. Contour plots showing pressure and temperature at given times within the object are also produced. By invoking axial symmetry, three-dimensional events can be modeled such as zero impact parameter collisions between asteroids. The code was tested against the one-dimensional model of Melosh (1987), and the analytical solutions of Grady and Kipp (1980) for a linearly increasing tensile stress under constant strain rate. The two-dimensional routine showed no systematic deviation from the analytic solutions, and a closer correlation than the one-dimensional results.

By comparing computational results from the hydrocode with data from actual laboratory impact experiments, it will be possible to both gauge the success of and further refine the collisional model. We will then gain a better predictive capability for the degree of fragmentation and for size and velocity distributions of fragments ejected in an impact event.

For testing of the hydrocode, two convenient laboratory experiments were a basalt-basalt collision and a pyrex-basalt collision done by Hartmann (1979, unpublished) at the Ames Vertical Gun Range (AVGR). In these cases, the specifics of the projectile/target mass, density, impact velocity (both <300 m/s), etc. were easily available. The cumulative fragment mass distributions predicted by the code in each case match the experimental outcomes acceptably well, considering inherent experiment scatter. Improved correlation should be possible with minor adjustments to the Grady-Kipp fragmentation algorithm. However, additional comparisons of the model to laboratory impacts covering a variety of velocities and materials will be necessary.

REFERENCES: Amsden, A.A., H.M. Ruppel, and C.W. Hirt (1980). Los Alamos Scientific Lab Report LA-8095. Grady, D.E. and M.E. Kipp (1980). Int. J. Rock Mech. Min. Sci. and Geomech. Abstr. 17. Melosh, H.J. (1987). Int. J. Impact Engng 5, 483-492.